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**CHEMISTRY
HIGHER LEVEL
PAPER 1**

Tuesday 8 May 2012 (afternoon)

1 hour

INSTRUCTIONS TO CANDIDATES

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- The periodic table is provided for reference on page 2 of this examination paper.
- The maximum mark for this examination paper is *[40 marks]*.

The Periodic Table

1	2	3	4	5	6	7	0
1 H 1.01	Atomic number						2 He 4.00
Element							
Relative atomic mass							
3 Li 6.94	4 Be 9.01						9 F 19.00
11 Na 22.99	12 Mg 24.31						17 Cl 35.45
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc 98.91	44 Ru 101.07
55 Cs 132.91	56 Ba 137.34	57 † La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.21
87 Fr (223)	88 Ra (226)	89 ‡ Ac (227)					
†							58 Ce 140.12
							59 Pr 140.91
							60 Nd 144.24
							61 Pm 146.92
							62 Sm 150.35
							63 Eu 151.96
							64 Gd 157.25
							65 Tb 158.92
							66 Dy 162.50
							67 Ho 164.93
							68 Er 167.26
							69 Tm 168.93
							70 Yb 173.04
							71 Lu 174.97
‡							90 Th 232.04
							91 Pa 231.04
							92 U 238.03
							93 Np (237)
							94 Pu (242)
							95 Am (243)
							96 Cm (247)
							97 Bk (247)
							98 Cf (251)
							99 Es (254)
							100 Fm (257)
							101 Md (258)
							102 No (259)
							103 Lr (260)

1. How many atoms of hydrogen are in 0.500 mol of CH_3OH molecules?

- A. 1.20×10^{23}
- B. 3.01×10^{23}
- C. 6.02×10^{23}
- D. 1.20×10^{24}

2. Calcium carbonate reacts with hydrochloric acid according to the following equation.



What is the theoretical yield, in mol, of calcium chloride if 0.10 mol CaCO_3 is added to 100 cm^3 of 1.0 mol dm^{-3} HCl ?

- A. 0.050
- B. 0.10
- C. 0.20
- D. 0.50

3. A fixed mass of an ideal gas at 27.0°C and $1.01 \times 10^5 \text{ Pa}$ has a volume of 100 cm^3 . Which change doubles the volume of the gas?

- A. Heating the gas at constant pressure to 54.0°C .
- B. Heating the gas at constant pressure to 327°C .
- C. Increasing the pressure on the gas to $2.02 \times 10^5 \text{ Pa}$ at constant temperature.
- D. Heating the gas to 54.0°C and increasing the pressure to $2.02 \times 10^5 \text{ Pa}$.

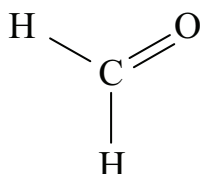
4. Which isotope has an atomic number of 9 and a mass number of 19?
- A. ${}^9\text{F}$
- B. ${}^{19}\text{K}$
- C. ${}^{19}\text{F}$
- D. ${}^{28}\text{Si}$
5. What is the order in which the energy sub-levels are occupied according to the Aufbau principle?
- A. 5s, 5p, 4d
- B. 4d, 5s, 5p
- C. 5s, 4d, 5p
- D. 5s, 5d, 5p
6. Which species are in the order of **increasing** ionic radius?
- A. $\text{Cl}^- < \text{K}^+ < \text{S}^{2-}$
- B. $\text{K}^+ < \text{Cl}^- < \text{S}^{2-}$
- C. $\text{Cl}^- < \text{S}^{2-} < \text{K}^+$
- D. $\text{S}^{2-} < \text{Cl}^- < \text{K}^+$
7. Which combination of descriptions is correct for the oxides of period 3 elements?

	Chlorine	Magnesium	Silicon	Sodium
A.	basic	acidic	basic	acidic
B.	acidic	basic	basic	basic
C.	basic	acidic	acidic	acidic
D.	acidic	basic	acidic	basic

8. What are the electron configurations of Cu, Cu⁺ and Cu²⁺?

	Cu	Cu⁺	Cu²⁺
A.	[Ar] 4s ² 3d ⁹	[Ar] 4s ² 3d ⁸	[Ar] 4s ² 3d ⁷
B.	[Ar] 4s ² 3d ⁹	[Ar] 4s ¹ 3d ⁹	[Ar] 3d ⁹
C.	[Ar] 4s ² 3d ⁹	[Ar] 3d ¹⁰	[Ar] 3d ⁹
D.	[Ar] 4s ¹ 3d ¹⁰	[Ar] 3d ¹⁰	[Ar] 3d ⁹

9. What is the correct number of centres of negative charge for carbon and the shape of H₂CO?



	Centres of negative charge on C-atom	Shape
A.	3	trigonal pyramidal
B.	3	trigonal planar
C.	4	trigonal pyramidal
D.	4	trigonal planar

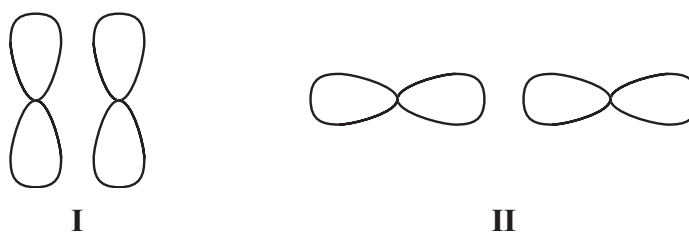
10. Which statement about intermolecular forces is correct?

- A. The intermolecular force between H₂ molecules is hydrogen bonding, because H₂ has temporary dipoles.
- B. The intermolecular forces between PH₃ molecules are greater than the intermolecular forces between NH₃ molecules, because they have a greater mass.
- C. The intermolecular force between H₂ molecules is hydrogen bonding, because H₂ has permanent dipoles.
- D. The intermolecular forces between Br₂ molecules are van der Waals', because Br₂ has temporary dipoles.

11. Which substances are soluble in hexane, C_6H_{14} ?

- I. C_8H_{18}
 - II. CH_4
 - III. H_2O
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

12. Diagrams I and II show two p orbitals on adjacent atoms in different relative orientations.



Which types of bonds are formed when the orbitals overlap?

	Orientation I	Orientation II
A.	σ	σ
B.	π	π
C.	π	σ
D.	σ	π

13. Which molecules have delocalized π electrons?

- I. C_6H_6
 - II. CH_3COOH
 - III. O_3
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

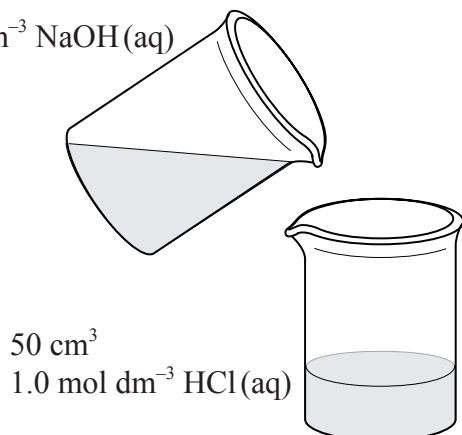
14. What are the units for specific heat capacity?

- A. kJ kg K
- B. kJ kg K^{-1}
- C. $\text{kJ kg}^{-1} \text{K}$
- D. $\text{kJ kg}^{-1} \text{K}^{-1}$

15. In each of two different experiments, A and B, a solution of sodium hydroxide is added to a solution of hydrochloric acid. The initial temperature of each solution is 25°C .

50 cm^3

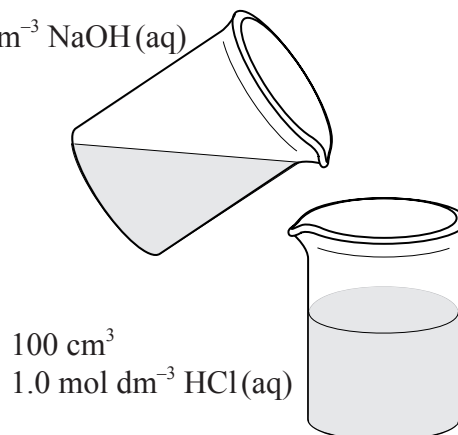
$1.0\text{ mol dm}^{-3}\text{ NaOH(aq)}$



Experiment A

50 cm^3

$1.0\text{ mol dm}^{-3}\text{ NaOH(aq)}$

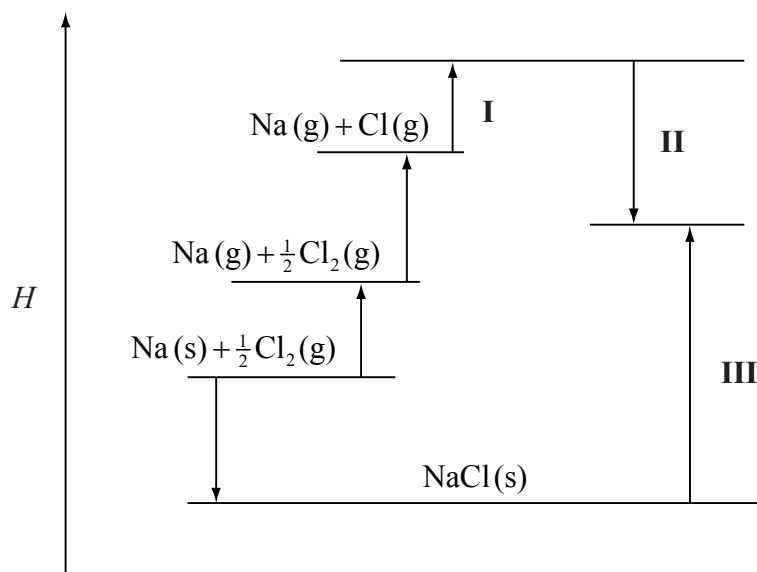


Experiment B

Which statement is correct?

- A. The highest recorded temperature of experiment A is lower than the highest recorded temperature of experiment B.
- B. The highest recorded temperature of both experiments is equal.
- C. The heat produced in experiment A is lower than the heat produced in experiment B.
- D. The heat produced in both experiments is equal.

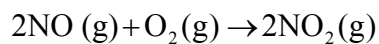
16. The diagram represents the Born–Haber cycle for the lattice enthalpy of sodium chloride.



What is the name of the enthalpy changes **I**, **II** and **III**?

	I	II	III
A.	ionization energy of Na	electron affinity of Cl	lattice enthalpy of NaCl
B.	lattice enthalpy of NaCl	ionization energy of Na	electron affinity of Cl
C.	electron affinity of Cl	ionization energy of Na	lattice enthalpy of NaCl
D.	ionization energy of Na	lattice enthalpy of NaCl	electron affinity of Cl

17. Which statements about entropy for the following reaction at 298 K are correct?

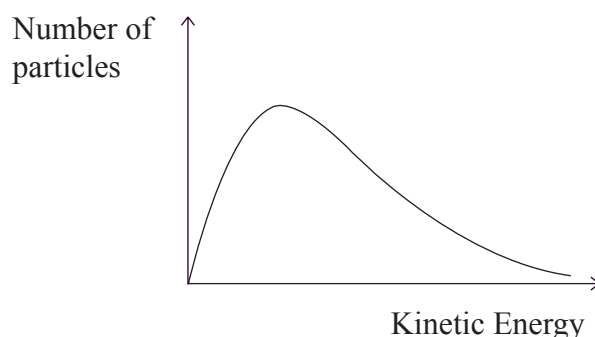


- I. $S^\ominus(\text{O}_2) = 0$
 II. $\Delta S^\ominus = 2S^\ominus(\text{NO}_2) - 2S^\ominus(\text{NO}) - S^\ominus(\text{O}_2)$
 III. $\Delta S^\ominus < 0$
- A. I and II only
 B. I and III only
 C. II and III only
 D. I, II and III

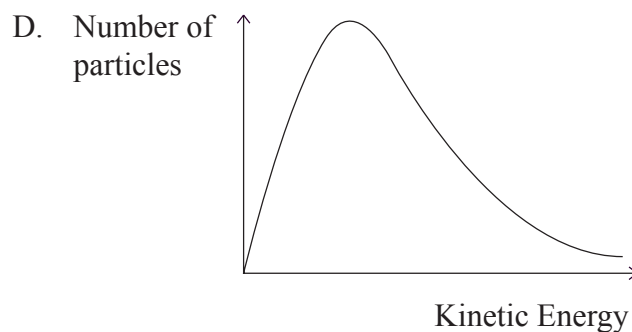
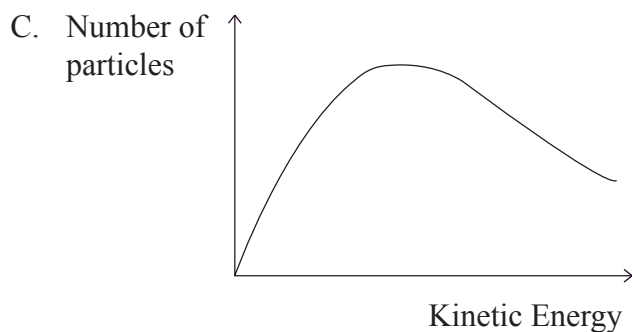
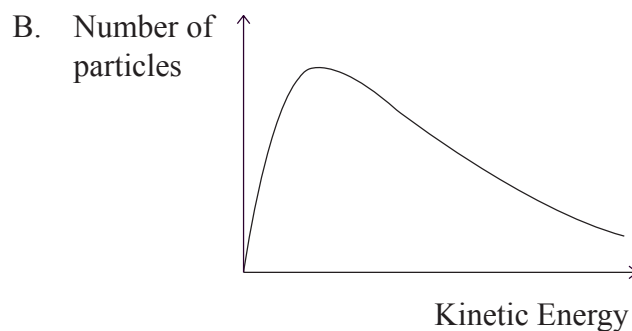
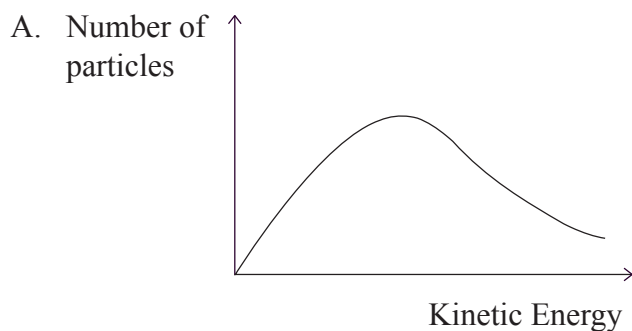
18. Which reaction is spontaneous at high temperatures, but not at low temperatures?

- A. $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$ $\Delta H < 0$
- B. $\text{CaCO}_3(\text{s}) \rightarrow \text{CO}_2(\text{g}) + \text{CaO}(\text{s})$ $\Delta H > 0$
- C. $\text{Fe}(\text{s}) + \text{Cl}_2(\text{g}) \rightarrow \text{FeCl}_2(\text{s})$ $\Delta H < 0$
- D. $2\text{C}(\text{s}) + 2\text{H}_2\text{O}(\text{g}) \rightarrow \text{CH}_3\text{COOH}(\text{l})$ $\Delta H > 0$

19. The Maxwell–Boltzmann curve below shows the distribution of kinetic energies for the particles in a sample of gas.



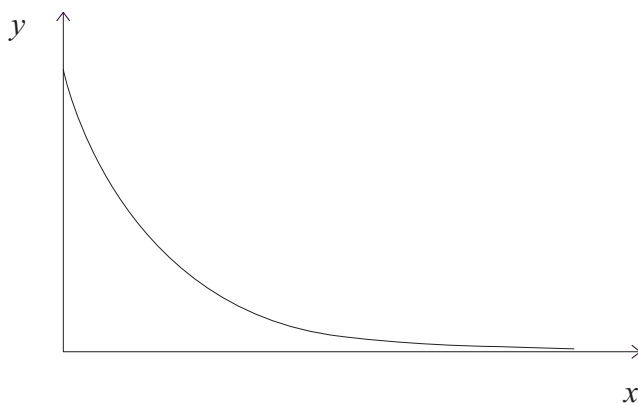
Which is the shape of the curve for the same sample of gas at a higher temperature? All graphs are drawn to the same scale.



20. The decomposition of N_2O_5 occurs according to the following equation.



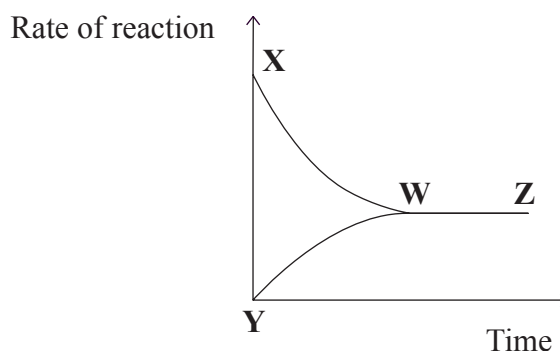
The reaction is first order with respect to N_2O_5 . What combination of variables could the axes represent on the graph below?



	x-axis	y-axis
A.	time	$[\text{N}_2\text{O}_5]$
B.	$[\text{N}_2\text{O}_5]$	time
C.	$[\text{N}_2\text{O}_5]$	rate of reaction
D.	rate of reaction	$[\text{N}_2\text{O}_5]$

21. What is the effect of an increase in temperature on the rate constant of the forward reaction, k , and on the equilibrium constant, K_c , of an exothermic reversible reaction?
- A. k decreases, K_c increases
- B. k increases, K_c decreases
- C. k decreases, K_c decreases
- D. k increases, K_c increases

22. The graph represents the rates of the forward and backward reactions of a reversible reaction.



Which statement is correct?

- A. **XWZ** represents the rate of the forward reaction.
 - B. At **Y**, the rate of the forward and backward reactions is zero.
 - C. Between **W** and **Z**, the concentrations of products and reactants are equal.
 - D. Between **Y** and **W**, the concentration of the reactants increases.
23. A liquid and its vapour are at equilibrium in a sealed container. Which of the following increase as the container is heated?
- I. The mass of the liquid.
 - II. The vapour pressure of the liquid.
 - III. The rate of vaporization of the liquid.
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

24. Which are conjugate acid/base pairs according to the Brønsted–Lowry theory?

- I. $\text{NH}_4^+/\text{NH}_3$
 - II. $\text{HCOOH}/\text{HCOO}^-$
 - III. $\text{H}_2\text{SO}_4/\text{SO}_4^{2-}$
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

25. An aqueous solution **X** reacts with a solid **Y**, to produce a flammable gas. Which of the following suggestions could substances **X** and **Y** be?

	X	Y
A.	nitric acid, HNO_3	calcium carbonate, CaCO_3
B.	sulfuric acid, H_2SO_4	zinc, Zn
C.	hydrochloric acid, HCl	copper, Cu
D.	sodium hydroxide solution, NaOH	aluminum oxide, Al_2O_3

26. Which is correct for a weak acid, HA , with concentration 0.01 mol dm^{-3} at 298K?

- A. $[\text{H}^+] < 1 \times 10^{-2}$
- B. $\text{pH} < 2$
- C. $[\text{OH}^-] < 1 \times 10^{-12}$
- D. $\text{pOH} > 12$

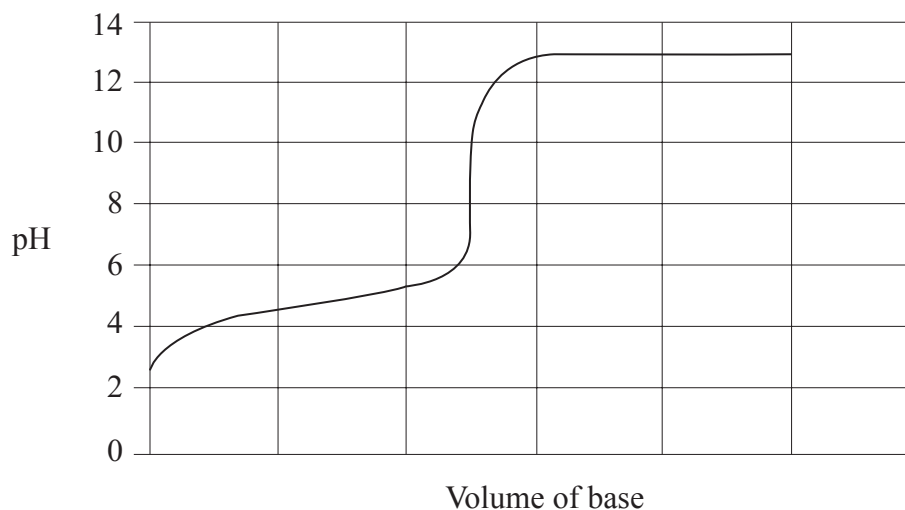
27. Which salt has the lowest pH when dissolved in water?

- A. KNO_3
- B. CH_3COONa
- C. Na_2CO_3
- D. $[\text{Fe}(\text{H}_2\text{O})_6]\text{Cl}_3$

28. Which of the following mixtures would result in the $\text{p}K_{\text{a}}$ of the acid being obtained from a direct pH measurement of the resulting solution?

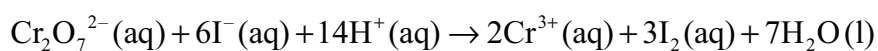
- A. 25 cm^3 0.1 mol dm^{-3} HCl and 25 cm^3 0.1 mol dm^{-3} NaCl
- B. 25 cm^3 0.1 mol dm^{-3} NaOH and 25 cm^3 0.1 mol dm^{-3} CH_3COOH
- C. 12.5 cm^3 0.1 mol dm^{-3} CH_3COOH and 25 cm^3 0.1 mol dm^{-3} NaOH
- D. 12.5 cm^3 0.1 mol dm^{-3} NaOH and 25 cm^3 0.1 mol dm^{-3} CH_3COOH

29. An aqueous solution of a weak acid containing an indicator is titrated with a strong base, resulting in the following titration curve.



At which pH does the buffer region occur?

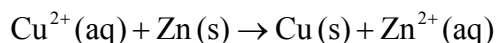
- A. Between 4.5 and 5.5
 - B. Between 7.5 and 9.5
 - C. At 9.5
 - D. At 12
30. The equation for the redox reaction between acidified dichromate and iodide ions is shown below.



Which is the reduction half-equation?

- A. $6\text{I}^{-}(\text{aq}) + 6\text{e}^{-} \rightarrow 3\text{I}_2(\text{aq})$
- B. $6\text{I}^{-}(\text{aq}) \rightarrow 3\text{I}_2(\text{aq}) + 6\text{e}^{-}$
- C. $\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 14\text{H}^{+}(\text{aq}) + 6\text{e}^{-} \rightarrow 2\text{Cr}^{3+}(\text{aq}) + 7\text{H}_2\text{O}(\text{l})$
- D. $\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 14\text{H}^{+}(\text{aq}) \rightarrow 2\text{Cr}^{3+}(\text{aq}) + 7\text{H}_2\text{O}(\text{l}) + 6\text{e}^{-}$

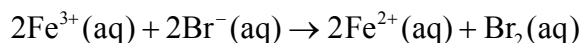
31. The equation for the overall reaction in a voltaic cell is:



Which statements are correct for this cell?

- I. Cu is the positive electrode.
 - II. Negative ions flow from the zinc solution to the copper solution.
 - III. Chemical energy is converted into electrical energy during this reaction.
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

32. Which statement is correct for the following spontaneous reaction?



- A. $\Delta E^{\ominus} < 0$ and Br_2 is a better oxidizing agent than Fe^{3+} .
- B. $\Delta E^{\ominus} < 0$ and Br^{-} is a better reducing agent than Fe^{2+} .
- C. $\Delta E^{\ominus} > 0$ and Fe^{3+} is a better oxidizing agent than Br_2 .
- D. $\Delta E^{\ominus} > 0$ and Fe^{2+} is a better reducing agent than Br^{-} .

33. Which combination of electrodes and electrolyte could be used to plate a spoon with silver?

	Negative electrode (cathode)	Positive electrode (anode)	Electrolyte
A.	silver	spoon	sulfuric acid solution
B.	spoon	silver	sulfuric acid solution
C.	silver	spoon	silver nitrate solution
D.	spoon	silver	silver nitrate solution

34. Which statements about $\text{CH}_3\text{CH}_2\text{CHO}$ are correct?

- I. It can be oxidized to $\text{CH}_3\text{CH}_2\text{COOH}$.
 - II. It can be produced by oxidation of $\text{CH}_3\text{CH}_2\text{OH}$.
 - III. It can be reduced to $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$.
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

35. Which reaction of but-2-ene produces 2-chlorobutane?

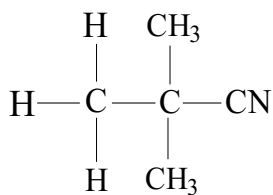
- A. Addition reaction with chlorine
- B. Substitution reaction with hydrogen chloride
- C. Substitution reaction with chlorine
- D. Addition reaction with hydrogen chloride

36. What are the correct names of the reaction types shown?



	I	II
A.	nucleophilic substitution	oxidation
B.	free-radical substitution	oxidation
C.	nucleophilic substitution	nucleophilic substitution
D.	free-radical substitution	nucleophilic substitution

37. What is the name of the substance below?



- A. Pentanenitrile
 - B. 2-methyl-2-propanenitrile
 - C. 2,2-dimethylpropanenitrile
 - D. 1,1-dimethylethanenitrile
38. What is the correct order of **increasing** rate of reaction between the following halogenoalkanes and a warm aqueous solution of sodium hydroxide?
- A. $\text{CH}_3\text{F} < \text{CH}_3\text{Cl} < (\text{CH}_3)_2\text{CHCl}$
 - B. $\text{CH}_3\text{Cl} < \text{CH}_3\text{F} < (\text{CH}_3)_2\text{CHCl}$
 - C. $\text{CH}_3\text{Cl} < (\text{CH}_3)_2\text{CHCl} < \text{CH}_3\text{F}$
 - D. $(\text{CH}_3)_2\text{CHCl} < \text{CH}_3\text{Cl} < \text{CH}_3\text{F}$
39. Which statements are correct for the nylon shown below?



- I. It is produced by condensation polymerization.
 - II. It is a polyamide.
 - III. One of its monomers is $\text{H}_2\text{N}(\text{CH}_2)_6\text{NH}_2$.
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

40. A student measured the mass of a solid on an analytical balance during an internally assessed IB practical experiment and recorded the mass in his raw data. The accuracy of the balance, as stated by the manufacturers, was ± 0.01 g. Which of the following choices would be the best record of his mass?
- A. 10.2 g
 - B. 10 g
 - C. 10.20 g
 - D. 10.200 g
-